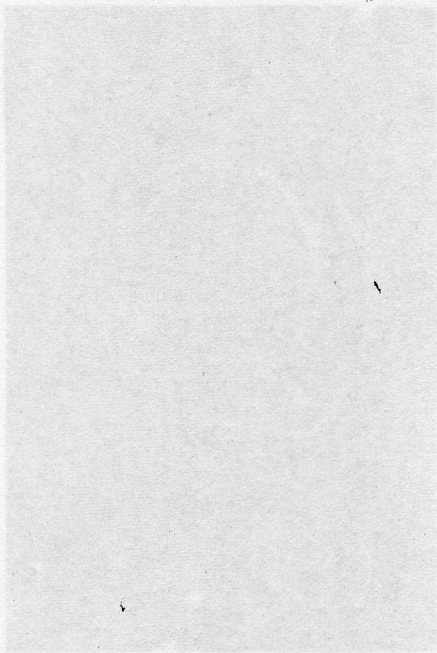
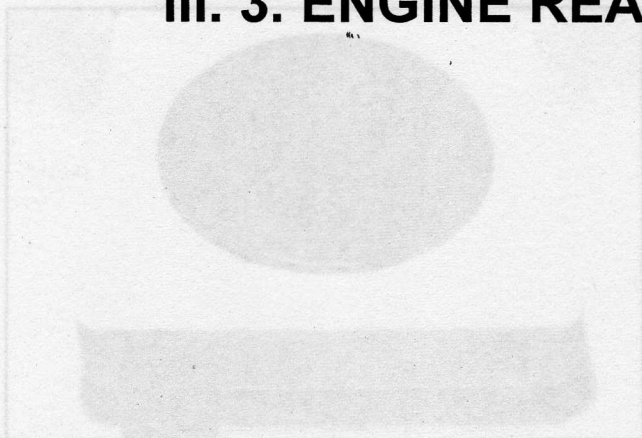


III. ENGINE REPAIR

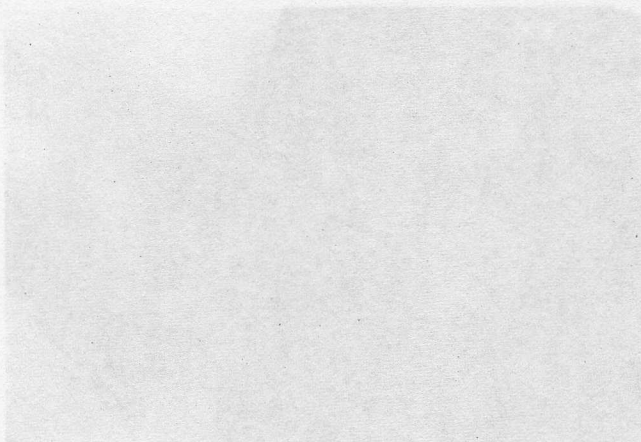


1. Crankcase
Press the bearing bush with driver. Take care that the joining line of the bearing bush is located as shown and that the oil holes in the bushing and the crankcase are properly lined up.
(Figure 1)

III. 3. ENGINE REASSEMBLY



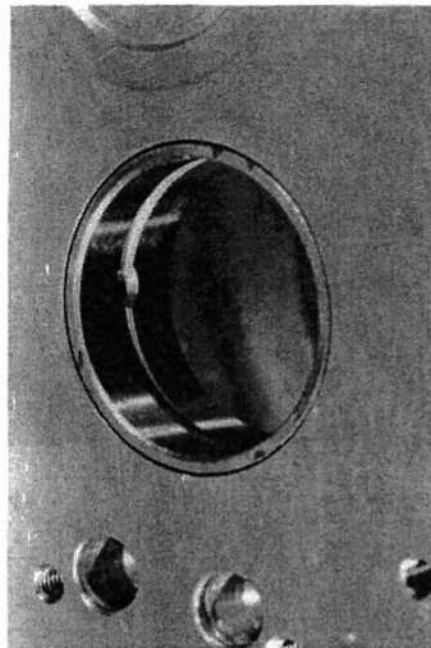
2. Crankshaft
To install the crankshaft gear wheel and the inner race of the roller bearing, heat the parts in an oil bath or on an electric heater plate to a temperature of 80 - 100°C (195 - 210°F). Thrust them down on the shaft using a suitable length of pipe and a hydraulic press.
(Figure 2)



Oil the bearing bush and slide the crankshaft into the housing. Take care not to damage the bearing bush with the gear teeth.
(Figure 3)

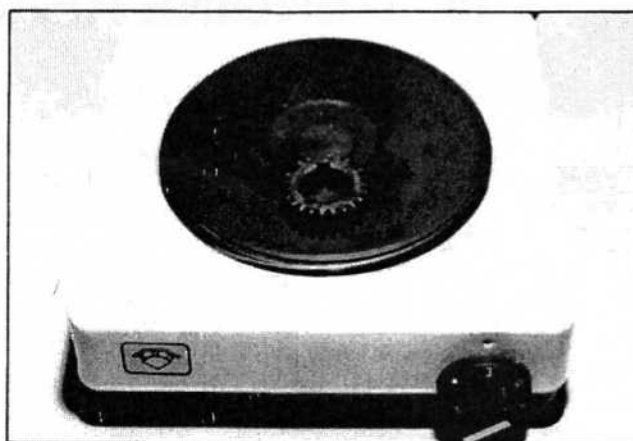
1. Crankcase

Press the bearing bush with driver. Take care that the joining line of the bearing bush is located as shown and that the oil holes in the bushing and the crankcase are properly lined up.
(Figure 1)

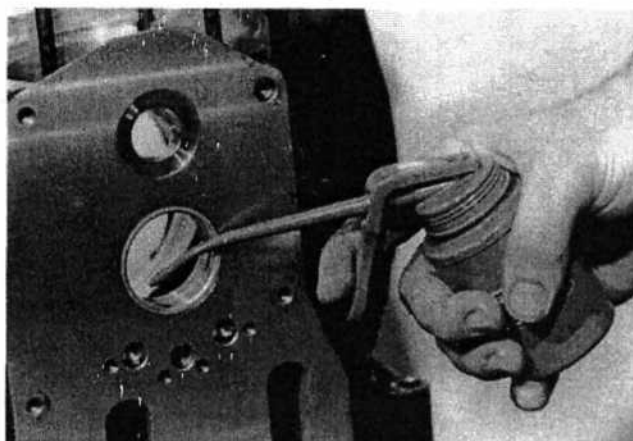


2. Crankshaft

To install the crankshaft gear wheel and the inner race of the roller bearing, heat the parts in an oil bath or on an electric heater plate to a temperature of 90 - 100°C (195 - 210°F). Thrust them down on the shaft using a suitable length of pipe and a hydraulic press.
(Figure 2)



Oil the bearing bush and slide the crankshaft into the housing. Take care not to damage the bearing bush with the gear teeth.
(Figure 3)

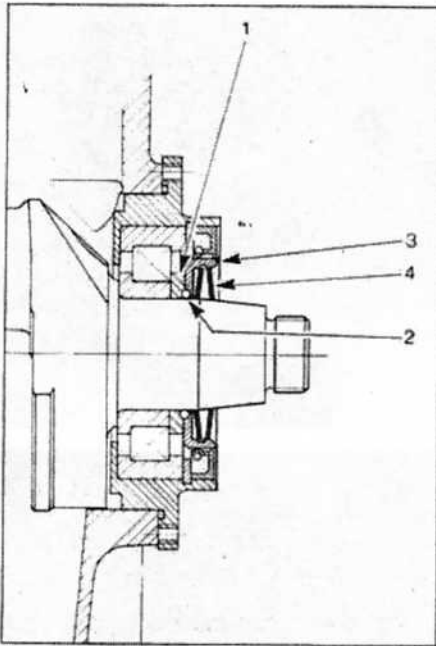


3. Main bearing cover

Press the outer race of the driver into the bearing cover. Insert the retaining ring with pliers. Press the oil sealing ring into the cover with driver. Before assembling oil crankshaft journal and the sealing ring lip, do not use grease. Insert o-ring in the bearing cover and put bearing cover onto stud.

Attention: Bearing cover can only be fitted in one position. Tap lightly with a soft faced hammer to seat the cover. Torque down the fastening nuts crosswise.

(Figure 4)



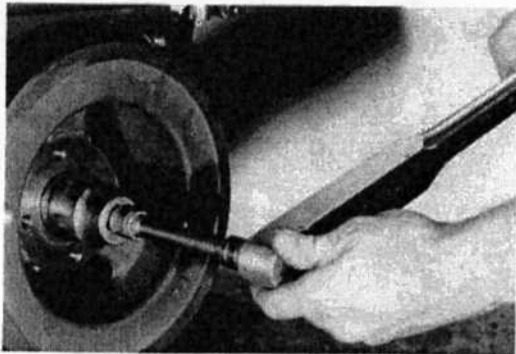
Assemble the thrust washer (1) and o-ring (2), followed by the angle ring (3) and the two belleville washers (4) exactly as shown.

(Figure 5)

4. Flywheel

Clean crankshaft and flywheel taper free of oil or grease. Insert the flywheel key and slide the flywheel onto the crankshaft taper. Assemble flywheel retaining nut and tighten to the specified torque.

(Figure 6)

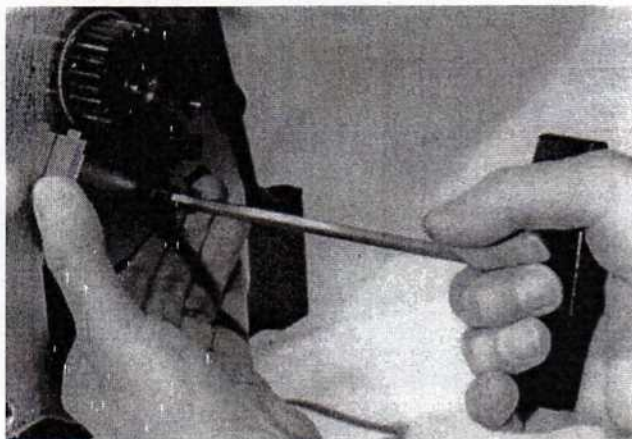


5. Oil pump

Reassemble oil pump with thin covering plate (only for securing bolts) and gasket. Before tightening the screws to the specified torque, pull the pump downwards. The clearance in the screw holes of the pump allows a sufficient backlash between the crankshaft gear and the pump gear.

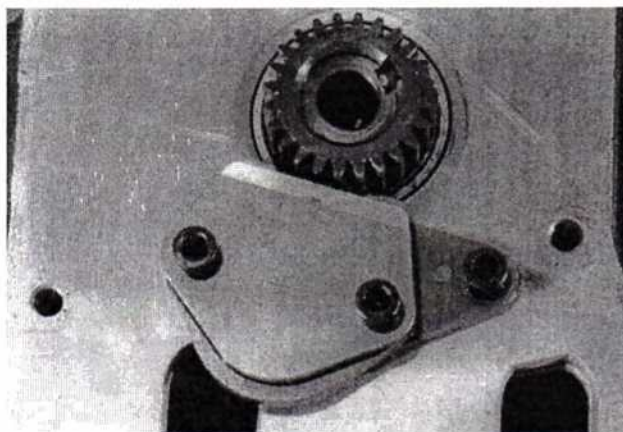
(Figure 7)

Attention: Engines with clockwise (B) and counter-clockwise (D) rotation have different pumps.



B: Pump gears are located on the left hand side, a yellow dot is visible on the front of the base plate on the right side.

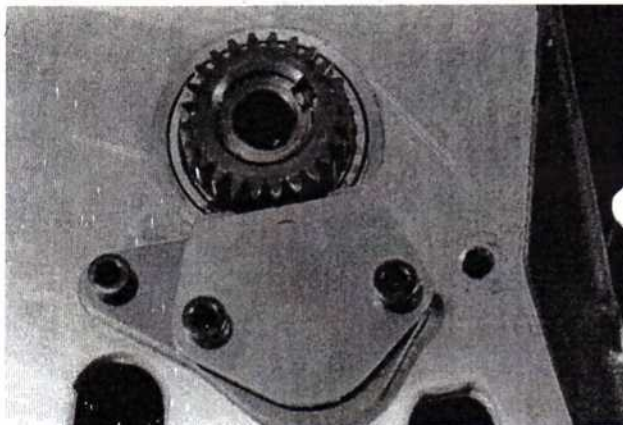
(Figure 8)



D: Pump gears are located on the right hand side, a „R“ is visible on the front of the base plate on the left side.

(Figure 8a)

The lefthand pump can easily be modified into a righthand pump: Punch out the straight pins, turn the base plate and reassemble the pump.



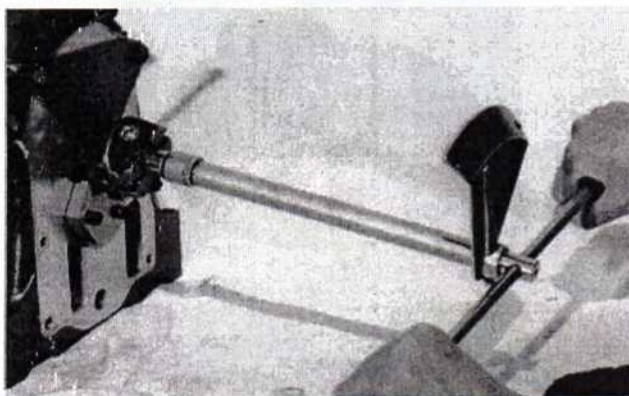
6. Governor

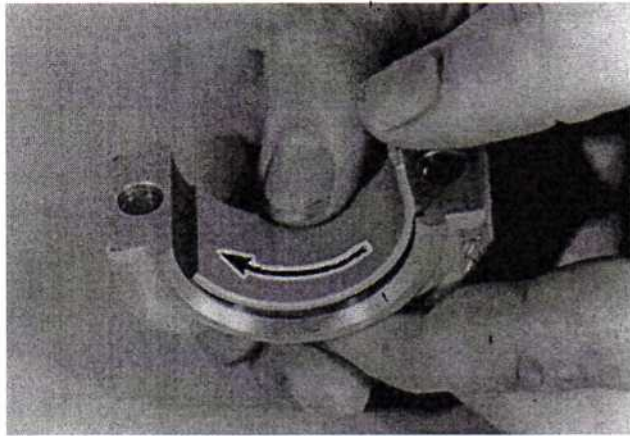
Install holding device so that all teeth fit exactly onto crankshaft. Make sure the governor and the crankshaft threads are free of oil and grease. Apply a couple of drops of Loctite No. 270 (or similar) on the governor threads. Torque the governor down according to engine specification.

Attention: The governor has a lefthand thread. While torquing, the socket must completely cover the governor screw head. Therefore spread flyweights.

Remove holding device after assembly. For exact governor adjustment refer to section III.6.

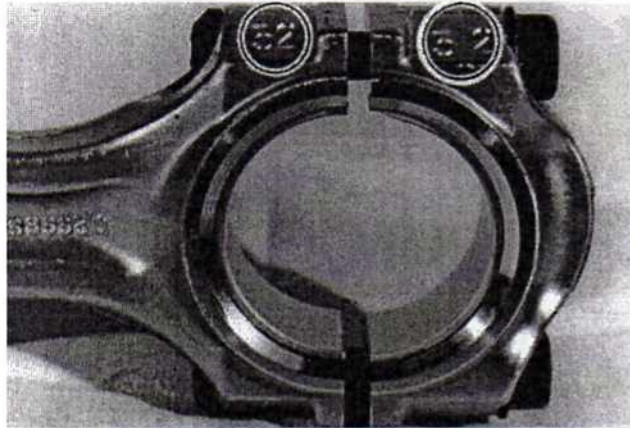
(Figure 9)



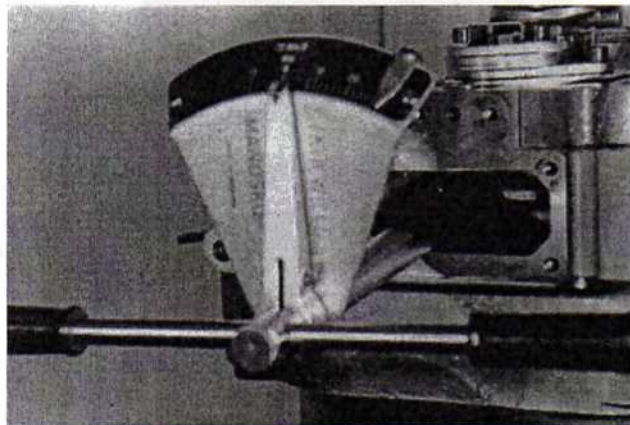


7. Connecting rod

To install new bearing shells, take a shell half and lay it to approx. $\frac{3}{4}$ into the cap. Now press with your thumb the bearing in a sliding movement onto its seat. The bearing lip must fit into the groove in the cap. The connection rod side shell half is installed the same way. (Figure 10)



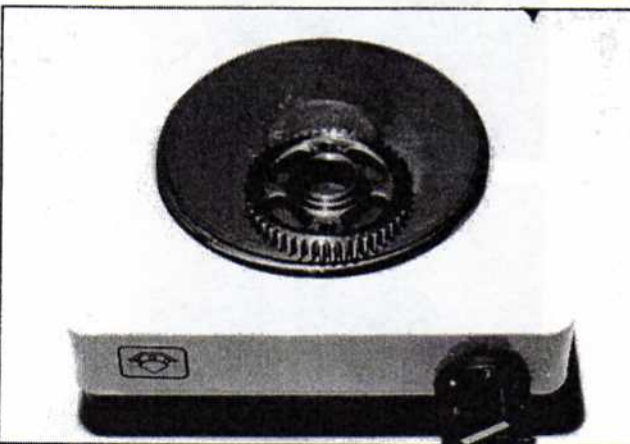
Notice the numbers stamped onto one side of the conrod. These are matching marks i.e. identical numbers must be on rod and cap. (Figure 11)



Oil the bearing shells and install conrod into the crankcase until it seats on the crank pin. Insert the conrod cap through the inspection cover.

Attention: The stamped numbers must be aligned on the same side of the rod but it is not important which engine side the numbers face. Tighten the conrod nuts to the specified torque and reinstall the crankcase cover.

(Figure 12)



8. Camshaft

Heat the camshaft gear wheel in an oil bath or an electric heater plate to 90-100°C (195-210°F). Thrust gear down onto the camshaft using a suitable length of pipe and a hydraulic press.

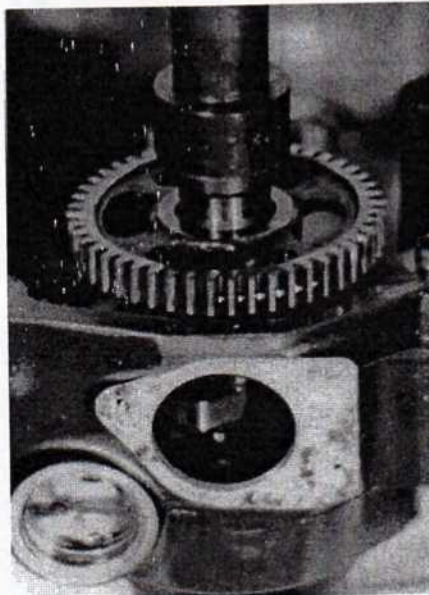
Attention: The chisel mark for the timing must face towards cam side of assembly.

(Figure 13)

Using a driver press the camshaft bearing into the gear cover.
(Figure 14)

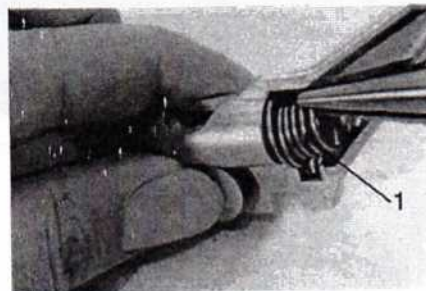


Now press the camshaft with driver into the bearing using a driver as a counter pressure piece for the bearing. Make sure that the bearing seats fully against the bearing seat flange. Insert the retaining ring. Install the camfollower for the injection pump and tighten its fixing screw. Do not forget to install a new o-ring on the camshaft prior to pressing the camshaft into the bearing.
(Figure 15)

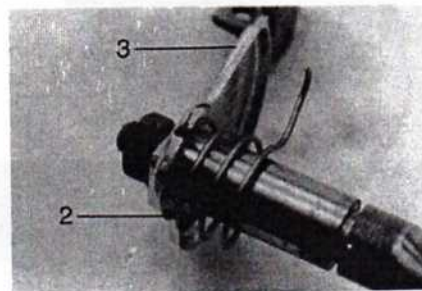


9. Governor control/speed Regulation Linkage

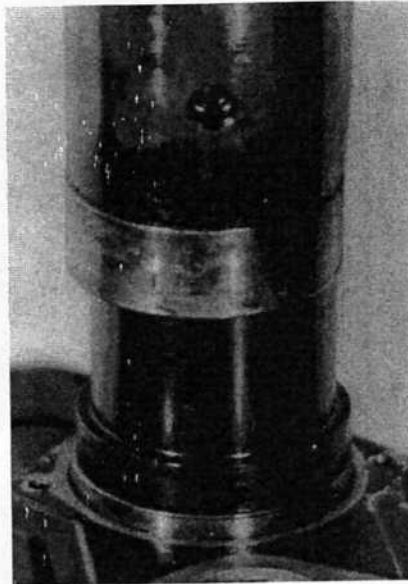
Insert ratchet pin and its spring into its hole in the gear housing and lay housing on work bench. Put the return spring into small hole of the control lever.
(Figure 16a)



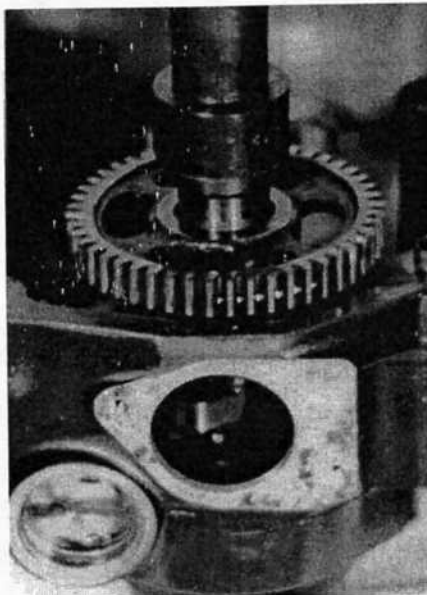
Move the torsion spring over the eccentric shaft and hook spring leg in the space in the middle of the ratched plate.
(Figure 16b)



Using a driver press the camshaft bearing into the gear cover.
(Figure 14)

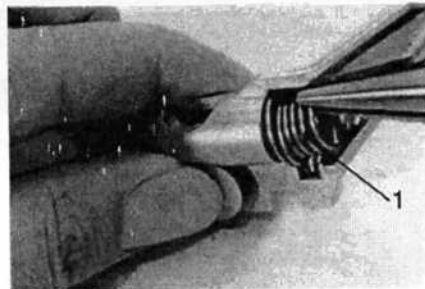


Now press the camshaft with driver into the bearing using a driver as a counter pressure piece for the bearing. Make sure that the bearing seats fully against the bearing seat flange. Insert the retaining ring. Install the camfollower for the injection pump and tighten its fixing screw. Do not forget to install a new o-ring on the camshaft prior to pressing the camshaft into the bearing.
(Figure 15)

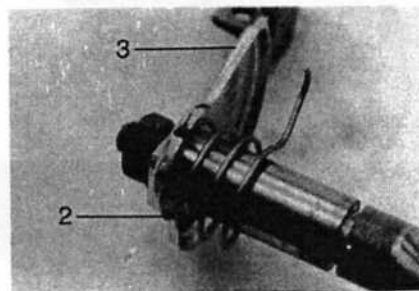


9. Governor control/speed Regulation Linkage

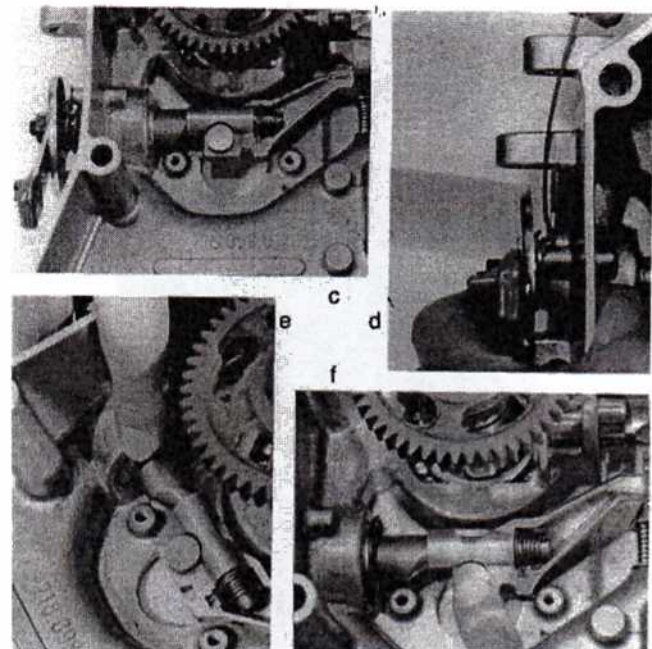
Insert ratchet pin and its spring into its hole in the gear housing and lay housing on work bench. Put the return spring into small hole of the control lever.
(Figure 16a)



Move the torsion spring over the eccentric shaft and hook spring leg in the space in the middle of the ratched plate.
(Figure 16b)



III. ENGINE REPAIR



Slide the eccentric shaft through the bearing bush in the housing and into the control lever. Turn the acceleration lever downwards („stop“-position) until spring leg of the return spring can be managed to get into the notch of the eccentric shaft. (Figure 16c)

Use a wire loop to move and hook torsion spring leg to the boss of the gear housing. (Figure 16d)

Push eccentric shaft further in and push ring spring into the notch of the eccentric shaft. (Figure 16e)

Attention: Initiate performance test.

The tension of the return spring must be acting against the pressure onto the binding screw. (Figure 16f)

Regulation - Stationary

The outer torsion spring pulls the acceleration lever from the stop - position back into the idle position.

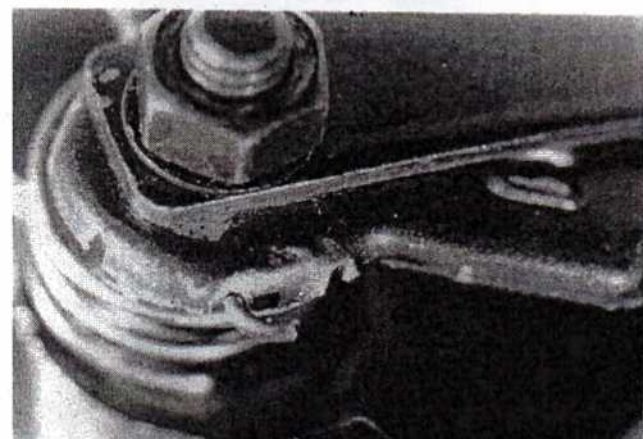
Regulation -

Vehicle/Bowden Cable

The outer torsion spring pulls the acceleration lever in the stop - position.

Attention: The spring tension may be altered by hooking the spring leg into one of the neighbored notches.

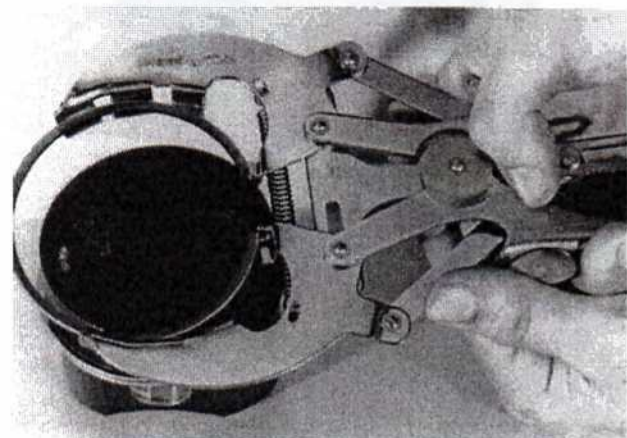
(Figure 17)



10. Piston

Install the piston rings using a ring expander so that the imprinted „R“ is on top.

(Figure 18)



Oil the ring and piston skirts. Check that piston ring gaps are 120 degrees offset. Compress rings with ring compressor. Lay the cylinder down on the bench with the bottom facing up. Install the piston into the cylinder from the bottom. Never tap on the piston crown.

Attention: Never try to install piston through top of cylinder liner as liner is slightly tapered. Push in the piston so far that the piston pin bore is slightly above edge of cylinder.

(Figure 19)



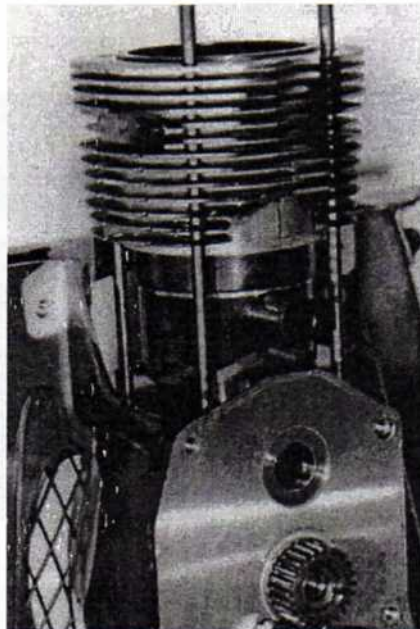
Slide the piston and cylinder over the studs with the crescent shaped sparing in the cylinder fins facing the gear side of the engine.

For 18B/D engines only:

The arrow stamped on the piston top must point towards the flywheel.

Align the piston and connecting rod bores. Push the piston pin in and insert the retaining ring. Push the cylinder down until it seats firmly onto the engine block.

(Figure 20)



11. Cylinder head

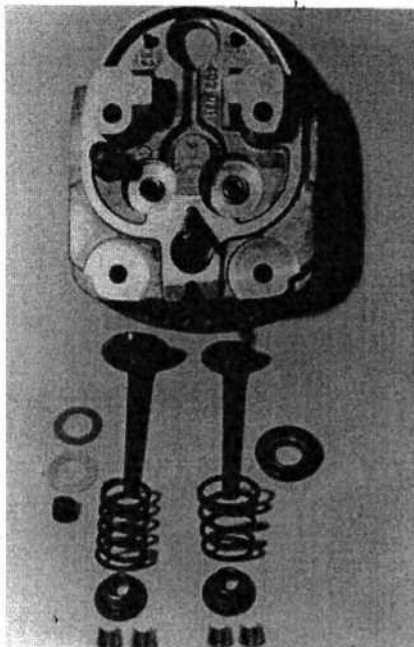
Press the valve guides into the cylinder head using driver (for protrusion dimension see III.2.17/

18). Special care is necessary to ensure that the guide is exactly vertical before pressing in.

Attention: Before pressing in exhaust valve guide, assemble the two small washers and retainer ring (the exhaust valve has the larger counterbore when viewed from top but the smaller valve diameter when viewed from the bottom).

(Figure 21)

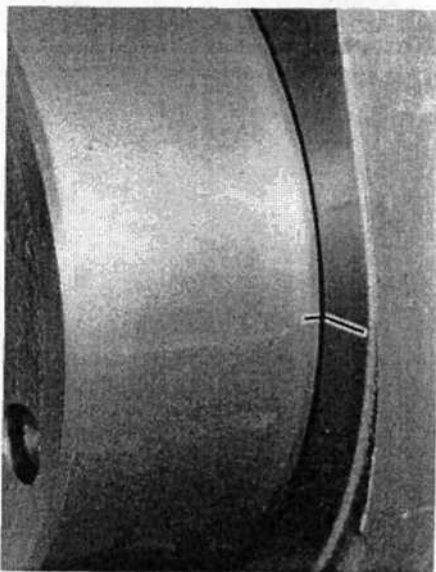




Grind in the valves. The rotocap and the conical shaped spring belong to the exhaust valve. The two thin steel washers must be under the cylindrical spring of the inlet valve. Fit new sealing cap onto the inlet valve guide. Before fitting the rotocap check for proper function: Spin the cap, if rattling sound or hard movement replace it.
(Figure 22)

Fit cylinder head gasket and slide cylinder head down onto the cylinder. Fit spring washers and cylinder head nuts. On the shorter stud bolt - intake side - fit the tote bracket and the cylinder head nut without spring washer.
(Figure 23)

Attention: Models 15B/D do not have any cylinder head gaskets.
At this stage do not torque down the cylinder head nuts as the rocker arms and push rods still have to be fitted at a later stage.



12. Gear cover

To install the gear cover, first bring the piston to TDC (Top dead center) by aligning the flywheel timing mark with the TDC mark stamped on the crankcase at the 3 o'clock position.
(Figure 24)

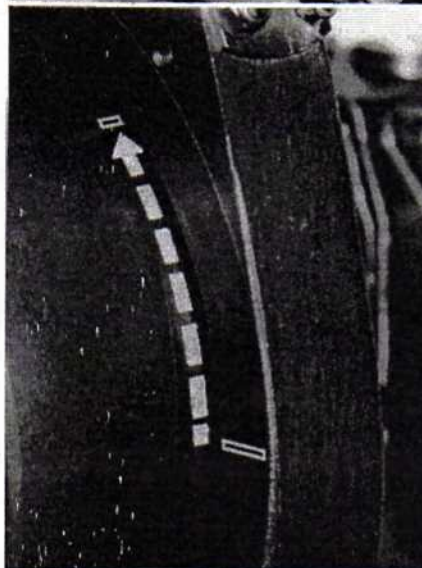
Insert the governor pin into the bore in the governor. Use grease to keep the pin in place. Line up the timing mark on the camshaft gear with the mark on the gear cover. (marks „A“ and „B“). Install the gear cover (remember to place the gaskets) onto the crankcase being careful not to move the camshaft gear. After the cover is installed, check the timing mark on the flywheel. If the crankcase and flywheel timing marks are within $\pm 2\text{mm}$ (± 0.0787) of lining up, the timing is correct (for governor adjustment refer to section III.6.) (Figure 25)



Occasionally, however, the governor will tighten onto the crankshaft in a position that makes it difficult to install the gear cover. If this happens, use the following procedure to install the cover:

- Turn the flywheel until its timing mark aligns with the treaded hole in the crankcase at approximately the 1 o'clock position.

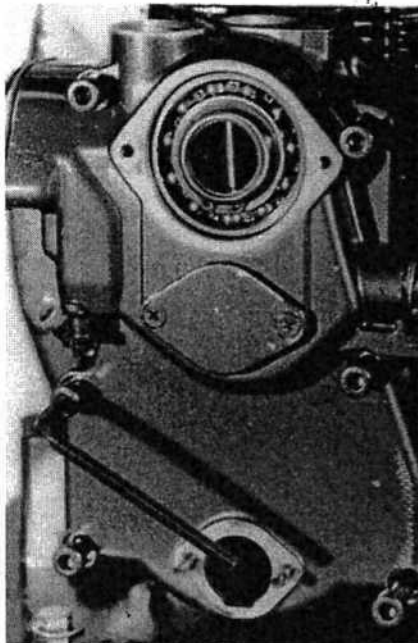
(Figure 26)



- Move the timing mark on the camshaft gear exactly 3 teeth to the left.

(Figure 27)





- Install the cover. Align the camshaft gear and gear cover timing marks. Now check the flywheel and crankcase timing marks. The timing is acceptable, if they are within ± 2 mm (± 0.0787) of each other.

When installing the gear cover screws, note that the top two and bottom left screw are longer than the other three. (Figure 28)

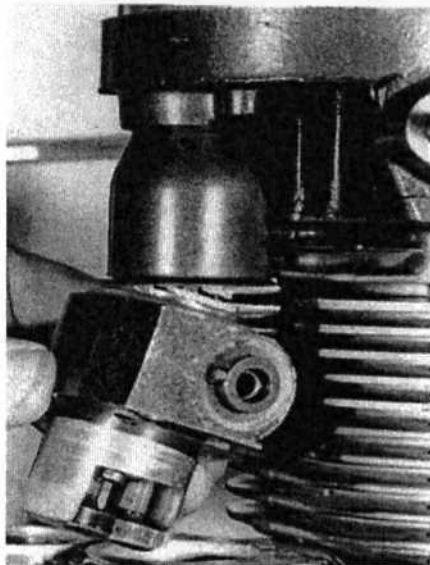
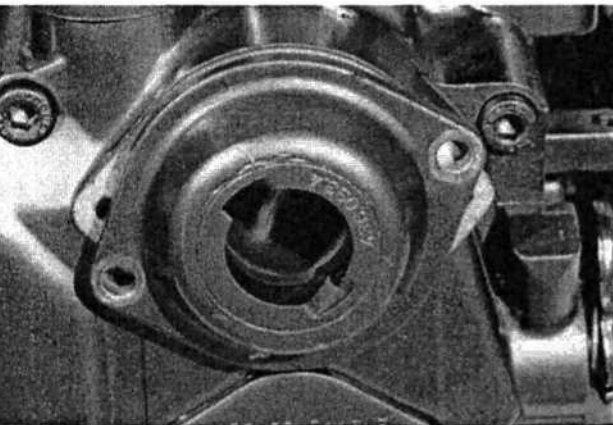
Place new o-ring in the flute of the support starting handle. Lubricate the camshaft and the sealing lips of the oil sealing ring. Do not push the guide straight onto the gear cover. Instead use a light twisting motion until the guide seats itself. Tighten the two guide screws to the specified torque. (Figure 29)

13. Compression release device

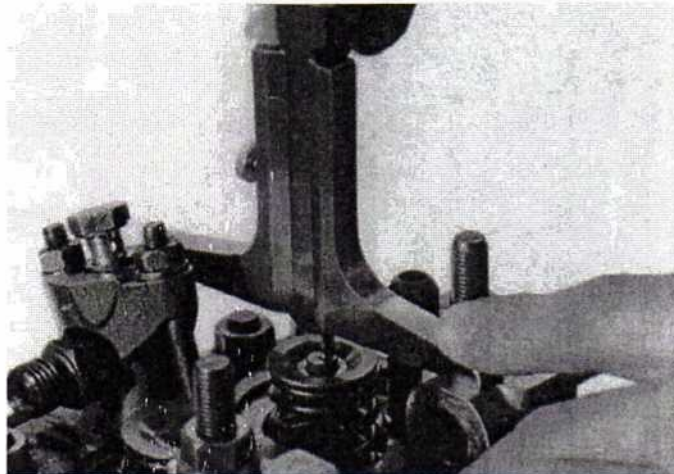
Slide the protection tube up into its hole in the cylinder head as far as possible. Remember to install a new o-ring in the cylinder head. Assemble the decompression device with new o-ring and gasket.

Attention: Before reinstalling the decompression device check if retaining pin for the shaft (arrow) is still in place.

(Figure 30)



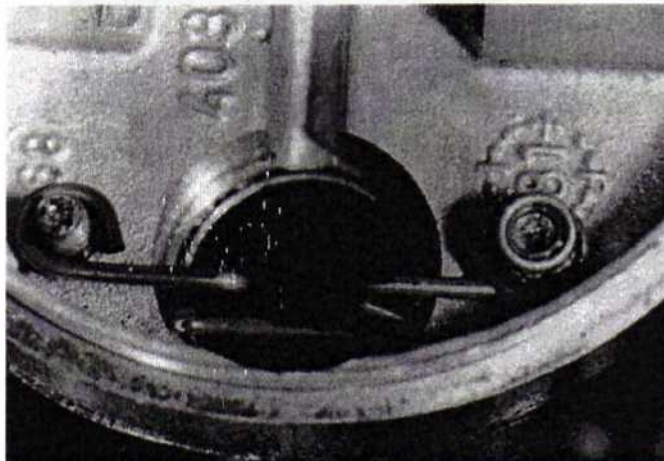
When a new decompression device is installed the correct function must be checked. To do so install the decompression device with the 0.4 mm (0.0157") thick gasket, continue with step 14, 15 and 16. Turn the piston approx. 1/8 revolution before TDC and measure with a depth gauge the distance between bracket for rocker arm shaft and spring collar of the inlet valve. Next, activate the decompression device and measure the distance again. There must be a difference between the two measurements of 0.7 - 0.9 mm (0.0236-0.384"). If it is less than 0.7 mm disassemble the decompression device and replace the 0.4 mm (0.0157") gasket with two 0.3 mm (0.0118") gaskets (in extreme cases use one 0.4 mm and one 0.3 mm gasket). Carry out the two measurements again. If the tolerance is more than 1.0 mm replace the 0.4 mm gasket with the 0.3 mm. Carry out the two measurements. (Figure 31)



14. Push rods and protection tube

Slide the protection tube down onto the decompression device. Assemble the retaining spring in the top of cylinder head exactly as shown but do not tighten the nuts yet. (Figure 32)

Insert the push rods through the protection tube into top of the decompression device. Both push rods are alike. The intake push rod goes into the hole in decompression device closest to cylinder.



III. ENGINE REPAIR



15. Rocker arms

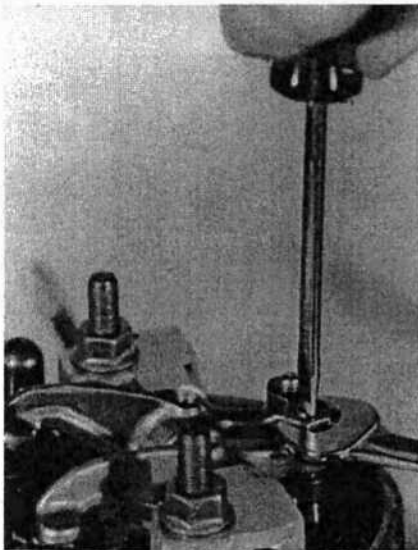
Place piston to TDC position. Line up rocker arms and push rods and oil the rocker arm bolt before installing it into the support.

Attention: To prevent damage of push rods while torquing the cylinder head nuts, ensure sufficient clearance between setting screw and push rods. Tighten the cylinder head nuts crosswise, in 3 steps, to the specified torque.

(Figure 33)

Tighten down the nuts for the retaining spring.

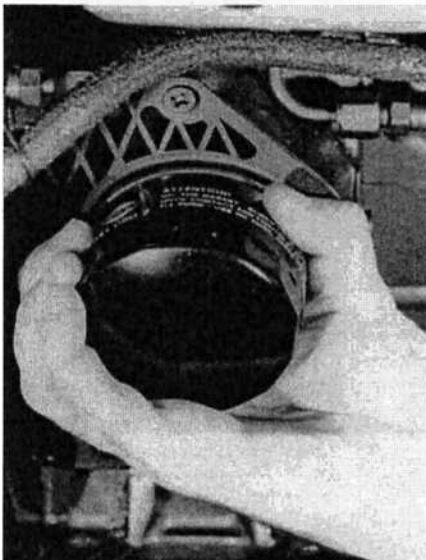
(Figure 32, page 51)



16. Valve adjustment

Check that the decompression device is not activated (pin is on 9 o'clock position). Set the piston on TCD compression stroke (see step 15). Loosen the locknuts of valve setting screws, insert a 0.1 mm (0.004") feeler gauge between the valve stem and rocker arm and adjust the clearance until a slight drag is felt on the gauge when pulled out. Tighten the locknut while holding the setting screw with a screwdriver. When finished recheck the clearance.

(Figure 34)



17. Oilfilter

Oil the rubber gasket of oilfilter and screw on oilfilter.

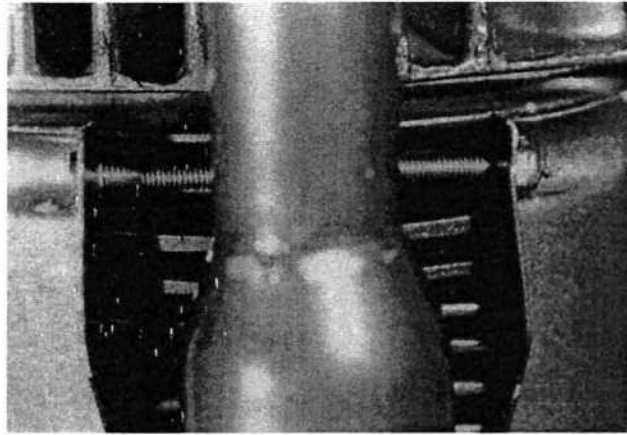
Attention: Hand-tighten oilfilter only.

Install oval flange of oil drain with gasket and screw plug. Fill the engine with new oil up to the upper dipstick mark.

(Figure 35)

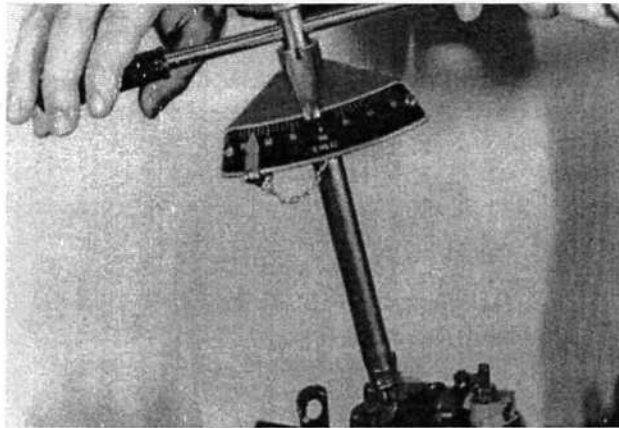
18. Cylinder shields and air guides

Install both halves of cylinder shields and the clamping bolt. Do not overtighten the bolt. It is sufficient when the bolt protrudes about 1-2 mm (0.0394"-0.0787") out of the locknut. Install the two air guides on top of the crankcase.
(Figure 36)



19. Fuel injector

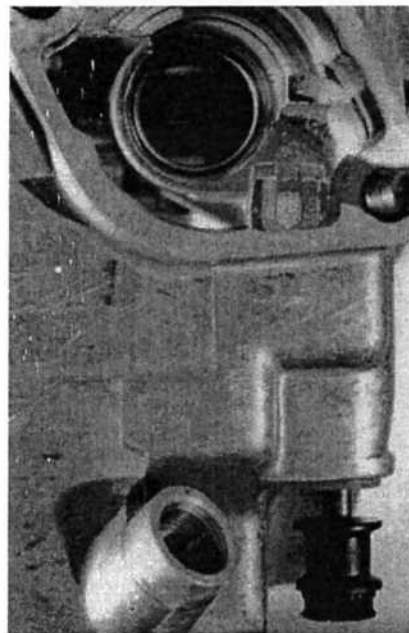
Replace the special washer located in the cylinder head fuel injector seat.
Attention: Use one gasket only, make sure that the old one has been taken out. Install the injector and the clamp. Torque the two nuts as specified.
(Figure 37)



20. Injection pump

Place acceleration lever in full load position and pull excess fuel button. The internal spring pushes the control lever against the housing. Place rod of the „fuel injection“. When sliding in the pump the pin of the rod directly grips into the yoke of the control lever. Reinstall the injection pump by using the same number and types of shims as were on the engine before (see III.5 for complete injection timing info.)

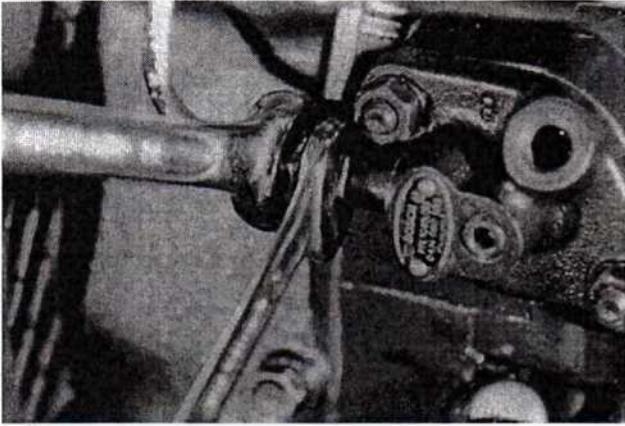
Attention: First install the paper gasket, then the shims onto the stud. Shims should not be in direct contact with the housing due to insufficient sealing function.
(Figure 38)



21. High pressure fuel pipe

Install the high pressure fuel pipe and tighten the union nuts on injector and pump. While tightening nut on pump and injector maintain counter parts with a 14 mm wrench.

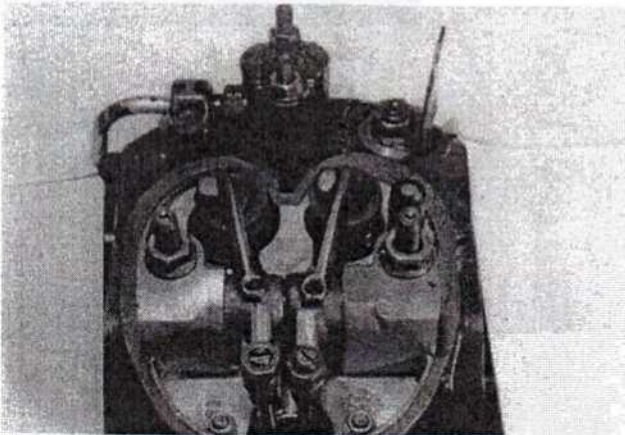
(Figure 39)



22. Valve cover

Install the valve cover gasket and the valve cover, making certain the gasket is properly seated on the cylinder head. Insert new plastic washers under the nuts and tighten to specified torque.

(Figure 40)

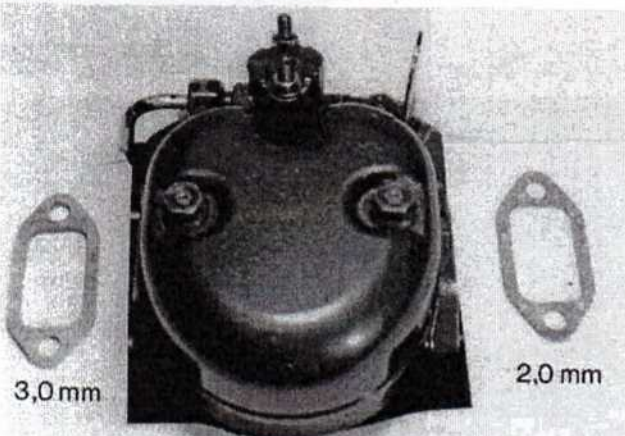


23. Fuel tank brackets

Reinstall the two brackets. Fit new gaskets on both sides of each bracket.

Attention: The exhaust and air filter gaskets are different. You need two gaskets for each bracket.

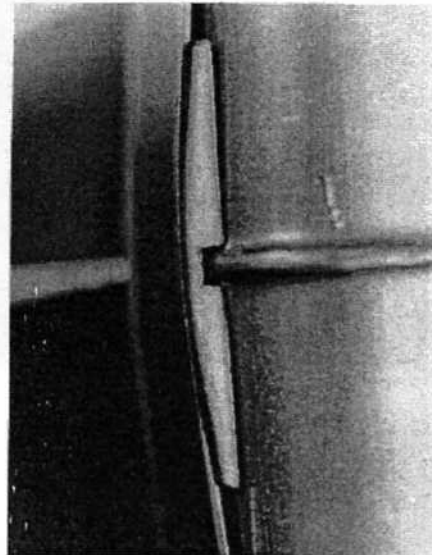
(Figure 41)



24. Fuel tank

Place the fuel tank on the tank brackets. Slide both tank straps over the tank and brackets. Do not forget to reinstall the two tank seam protectors. Tighten the straps.

(Figure 42)

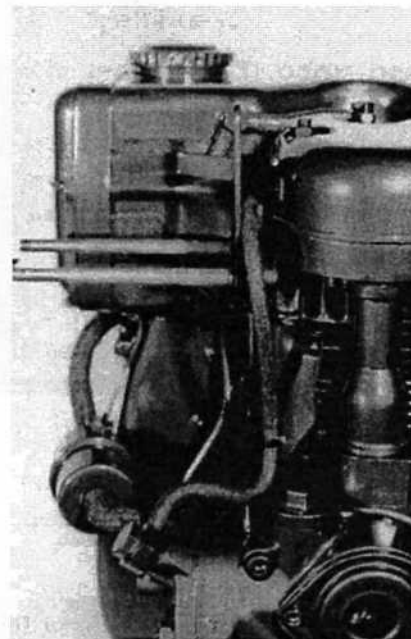


25. Fuel leak-off and supply line

Install banjo bolts on the fuel leak-off/supply line at the fuel tank and fuel injector. Remember to replace both copper washers on each banjo bolt. Route the fuel line as shown.

Attention: On the injector end the thicker copper washer is located between the injector and the end piece of the leak-off pipe.

(Figure 43)

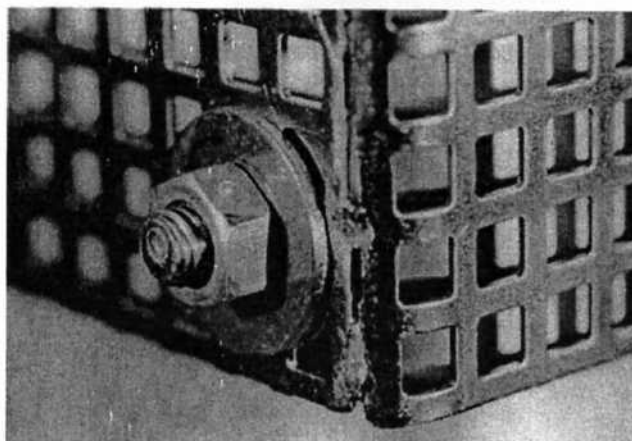


26. Air filter/Muffler

Using a new gasket and two new self locking nuts, install the air filter. Install the muffler and muffler screen.

Attention: Fit the two flat washers each bolt. One in front and one behind the muffler screen.

(Figure 44)



27. Test run

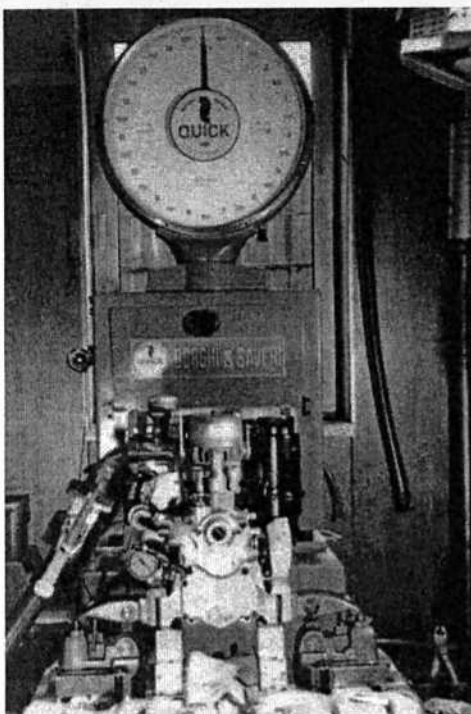
The engine is now completely reassembled. Install engine on a test bench and carry out a test run. The engine does not require a long time running-in program. After a short run according to below specifications the engine is ready for normal operation. Also the use of special break-in oils or lub. oil additives are **not** recommended.

(Figure 46)

Running-in instruction:

- 10 min. idle speed, no load
- 10 min. half speed, half load
- 20 min. fuel speed, full load
- 2 min. idle speed, (for cooling down)

During the test run, check for proper function, unusual noise and leakages. Low and high idle speed, full load speed, exhaust gas temperature, lub. oil temperature and lub. oil pressure should be recorded. After the test run change the lub.oil.



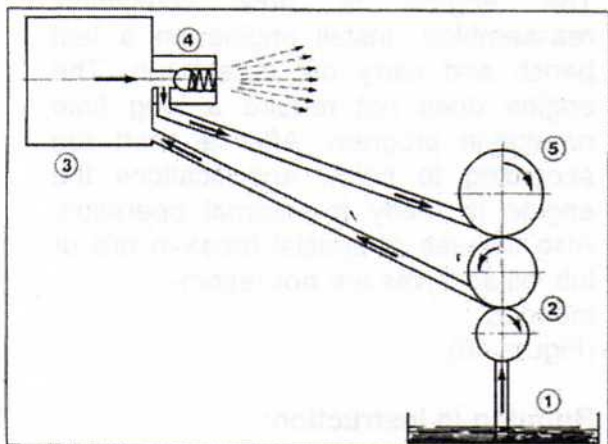


Figure 1



Figure 2

A gear pump (2) sucks the oil from the oil sump (1) and pumps it through the oilfilter (3) to the main bearing (5) and to the conrod bearing.

Piston, piston pin, cylinder liner and rocker arms are splash lubricated. When oil pressure rise above 4,5 bar (63 PSI) the oil pressure relief valve (4) opens and the oil flows back into the oil sump partly.

All **Farymann** engines require heavy duty lubrication oils of at least CC, preferably CD quality (API service classification).

For correct viscosity and oil change intervals refer to operation manual. At least once a year crankcase should be flushed to remove all dirt and abrasions that may be in the crankcase.

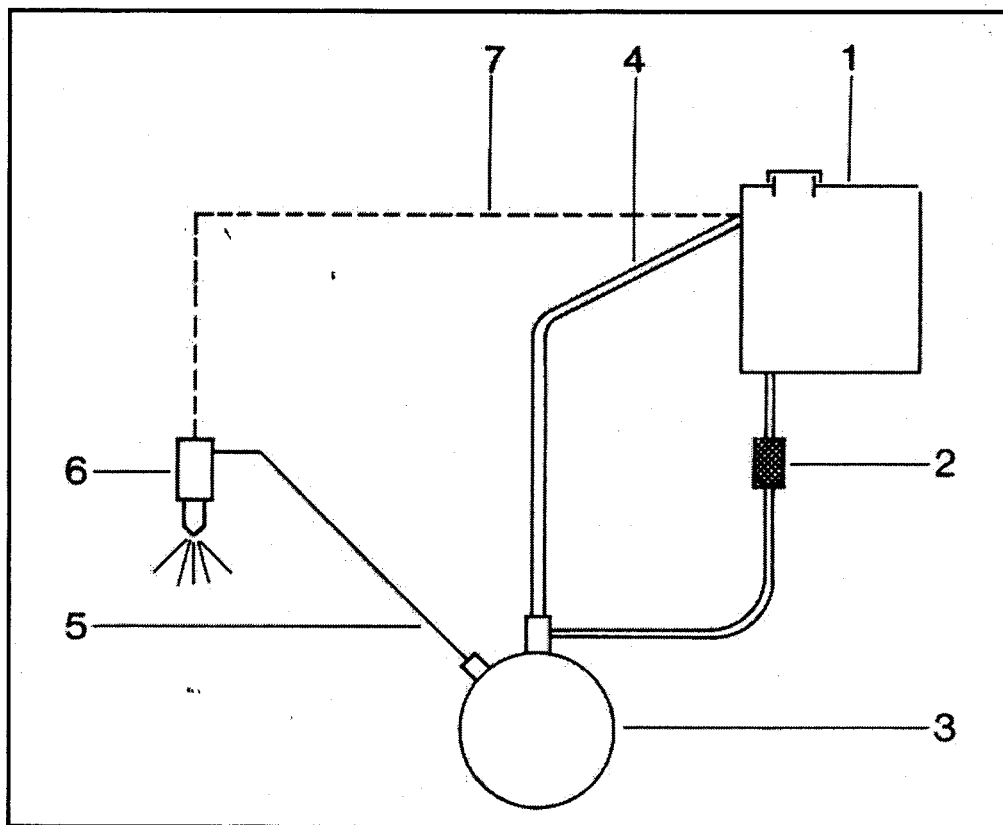
Oil pressure testing

The oil pressure depends mostly on the bearing play (see section III.2). Before oil pressure make sure that oil level is topped up and correct viscosity is used.

Remove the oil channel plug screw (Figure 2) and connect gauge adaptor and oil pressure gauge.

The oil pressure at idle speed should be at least 0.5 bar (7 PSI). At full load (2850 rpm and 100°C/220°F oil temperature) it should be at least 1.8. bar (23 PSI).

If oil pressure is too low, check first if the oil has the correct viscosity (according to the ambient temperature) and if the pressure relief valve is working before further dismantling of the engine.



The fuel flows from the tank (1) through the filter (2) to the injector pump (3). As the quality supplied is higher than required for the injection, most of it goes back to the tank via the return pipe (4), simultaneously carrying heat away from the pump.

Also the return pipe ensures a constant bleed of the fuel system.

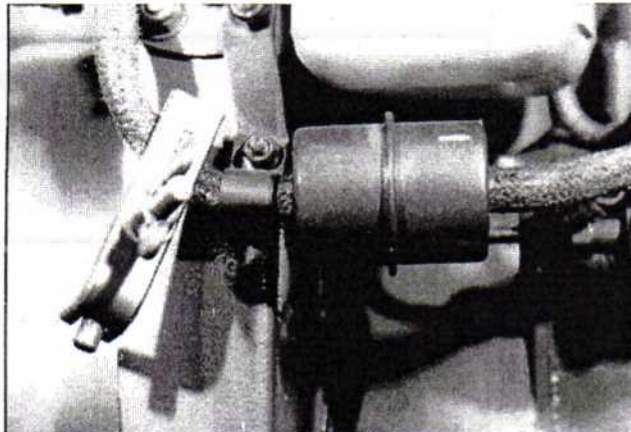
From the injection pump fuel is fed through the high pressure pipe (5) to the injector (6) and, in a fine mist, sprayed into the combustion space shortly before TDC of the compression stroke. A return pipe (7) carries back any leakage to the tank.

III.5.1. Fuel System

The fuel filter prevents the entry of dirt into the injection pump. The normal lifespan of the filter is approx. 2000 operation hrs., however, it depends on the purity of the fuel used.

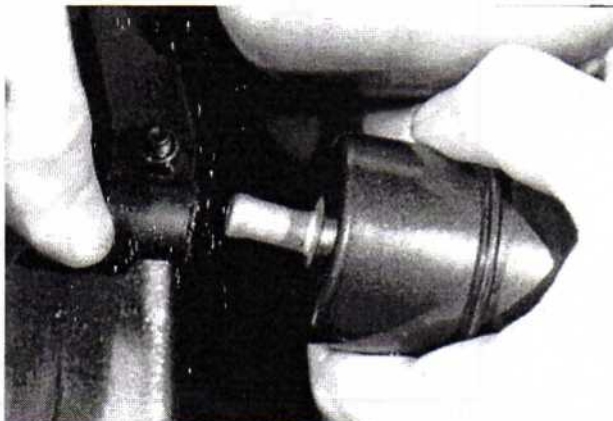
Prior to changing fuel filter, clean the fuel pipe from dirt with a rag and close off the line between tank and filter with clamp.

(Figure 21)



Pull the inlet and outlet lines from the filter.

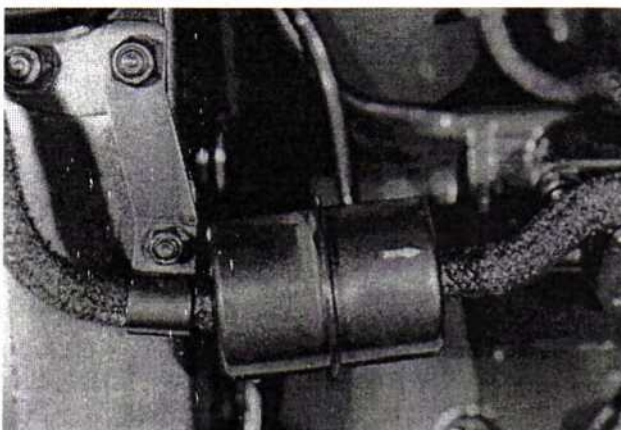
(Figure 3)



Take care that no dirt enters the pipes. Discard the used filter. Do not try to clean it! Push the pipes as far as possible onto the connection nipples of the filter.

Attention: Watch out for the correct direction of flow (arrow on filter housing)!

(Figure 4)



III.5.2. Injection nozzle

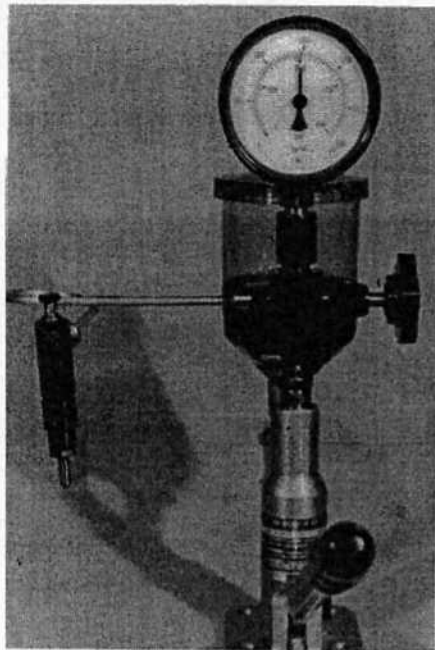
The injector nozzle injects the fuel in a fine mist and under a high pressure into the combustion space. Due to the high mechanical and thermal stress, the nozzle requires regular maintenance.

Carbon residues on the nozzle tip are removed with a brass wire brush.

The spray holes can be cleaned with a special needle (Bosch tool)

(Figure 5)





To check the injection pressure, connect the complete injector valve to a nozzle tester.

Pump with the hand lever till the nozzle ejects. The fuel must be ejected evenly atomized without dripping at the specified pressure.

(Figure 6)

Caution:

Keep hands away from nozzle spray!
The spray from a nozzle can penetrate deep into the flesh of the fingers or hand and destroy the tissues. Diesel oil entering the blood stream can cause blood poisoning.

If injection pressure is too high or too low, it must be corrected by replacing shims in the injector valve.

To do so dismantle the injector valve: Unscrew the sleeve nut (1), take off the nozzle (2), pressure piece (3), valve cone (4) and pressure spring (5).

(Figure 7)

Replace adjustment shims.

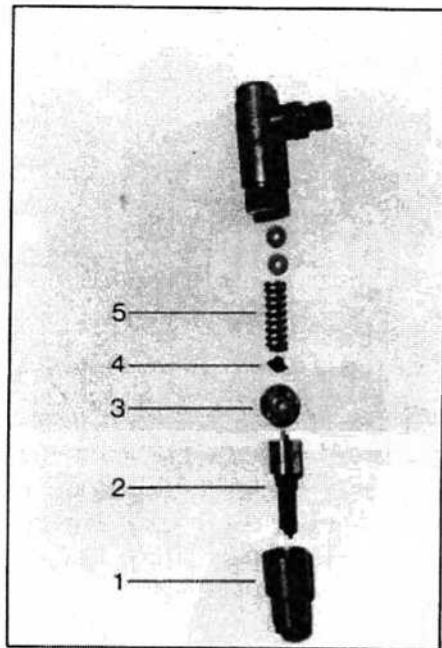
Thicker shims= higher pressure

Thinner shims= lower pressure

An alteration of 0.1 mm (.004") will bring a change of approx. 10 bar (145 PSI)

When reassembling take care that the pins on the pressure piece are correctly located in nozzle body and nozzle holder.

If the nozzle leaks, dribbles or does not atomize properly, change the complete nozzle. Lapping of the nozzle needle is not recommended.



III.5.3. Excess starting fuel button

For ease of starting all engines are fitted with an excess starting fuel pull button. (Figure 8)

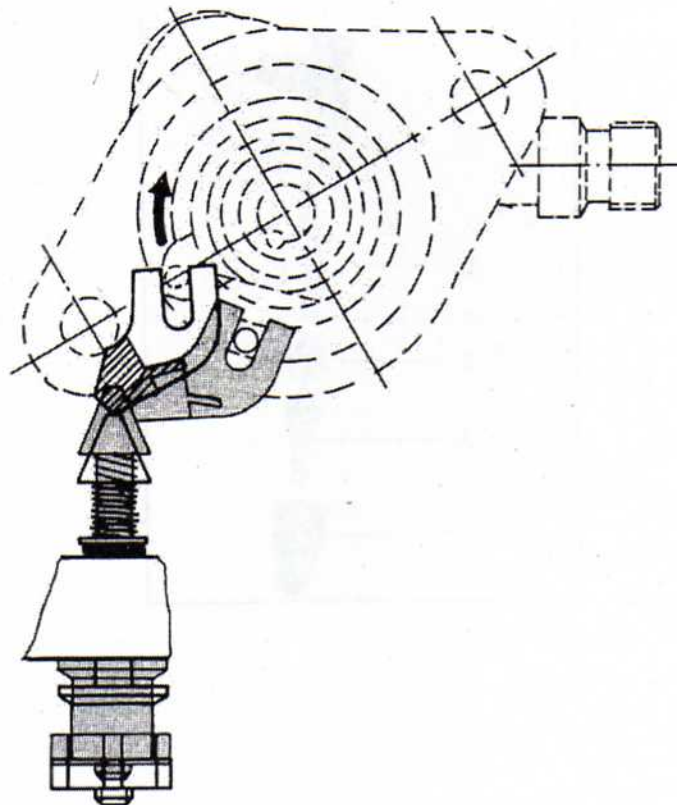
A cone limits the travel of the injector pump fuel rack. When the starting fuel button is pulled down prior to start, the cone allows the fuel rack to travel a longer way. (Figure 9)

As soon as the engine reaches its high idle speed the governor pushes the fuel rack towards stop, the starting fuel button disengages and returns to its normal position.

Therefore it is necessary to start the engine without load in order to reach maximum rpm. Otherwise the starting fuel button will not disengage and continuously overload the engine.

Also the engine output is adjusted via the cone of the starting fuel button. Depending in the installation depth of the cone the fuel rack travel is shorter (=less output) or longer (=higher output). **This output adjustment is done at the factory's test bench. Under no circumstance this setting should be altered.**

If the excess starting fuel button or the complete gearcover was renewed, the engine output must be readjusted on a testbench.



III.5.4. Adjustment of fuel injection timing

The correct setting of the commencement of delivery is a basic requirement for a troublefree function of the engine. As the injection timing is fixed, a check and respectively readjustment is only necessary when the engine speed was altered, a new injection pump was installed or the camshaft/camshaft gear was renewed.

Engines of model 15 and 18 are set at „delivery cut off point“.

First crank the engine in rotation direction to compression stroke till TDC mark on the flywheel is approx. at the 5 o'clock position. Remove the allen head screw from injector pump head and the sealing washer under it and fit drip tube. (Figure 10)

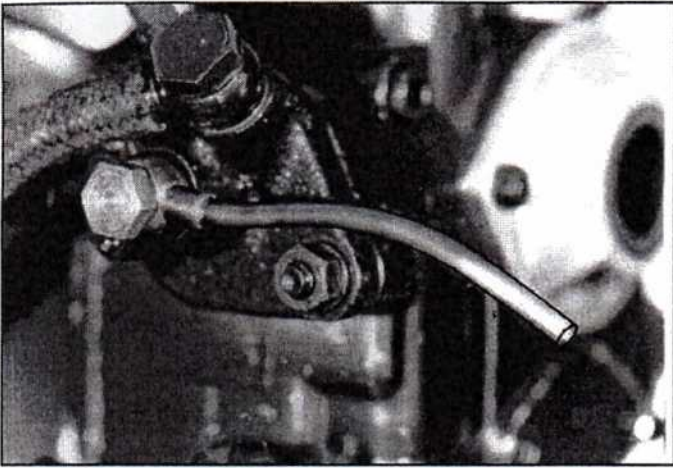
Attention: Fuel will flow out of the pump as soon as the screw is loosened.

Set acceleration lever at half load.

Attention: Excess starting fuel button must not be pulled.

Slowly crank the engine rotationwise and observe the drip tube. First the fuel flows free out of it, drips, stops and starts to drip again. The delivery cut-off point is reached when approx. 1 drop per second comes out of the tube.

(Figure 11)



III. ENGINE REPAIR

Use a flexible ruler and measure the distance between TDC marks on the flywheel and housing.
(Figure 12)

Compare the measurement with the valves at the table III.8 observing the correct flywheel diameter and engine speed. If the measured value is out of tolerance, readjust the commencement of delivery, either by adding or removing shims under the injection pump. Adding shims shortens the distance (=delayed injection), removing shims increases (=advanced injection) the distance between the TCD marks.

If shims have been added respectively removed, or a new injection pump is has been fitted, the installation depth must be checked.

Measure from the mounting flange down to the **edge** in the roller tappet (**not down to the roller**). This measurement plus the thickness of the shims should be between 57.5 mm (2.263") and 59.1 mm (2.327").

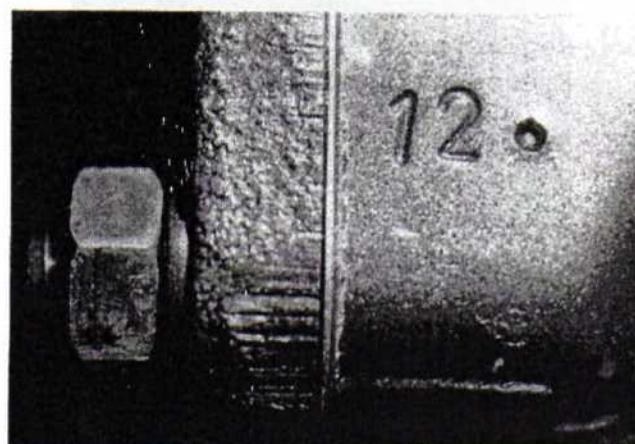
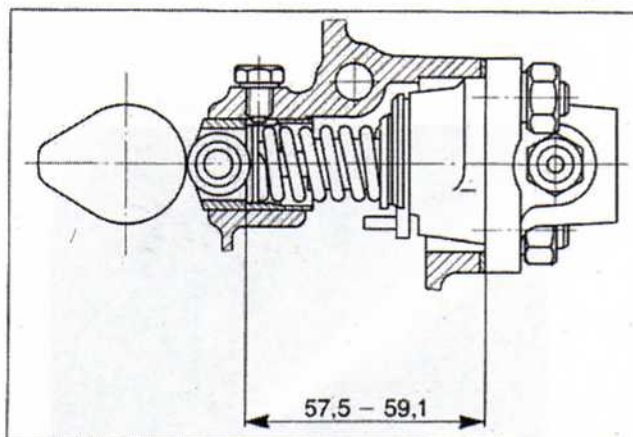
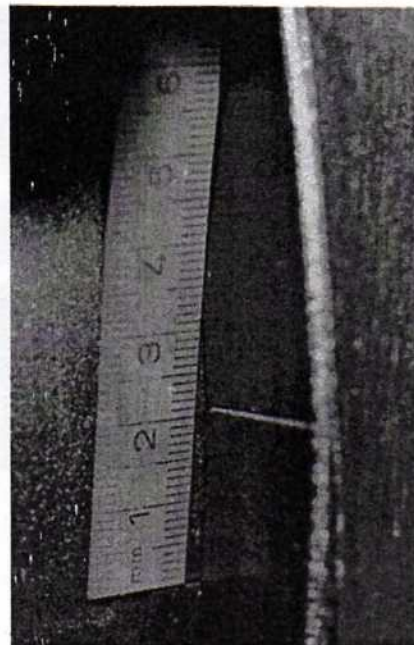
(Figure 13)

If it is not possible to set the injection timing via the shims, then most probably the alignment of the camshaft gear is not correct (see III.3.12) or the TDC mark is wrong.

Attention: The thickness of the shims fitted under the pump is stamped on the mounting flange of the injector pump in 1/10 mm.

e.g. 12 = 1.2. mm. This value, however, refers only to the originally fitted pump. When a pump has been changed or the injection timing was altered, the new corrected thickness should be stamped on.

(Figure 14)



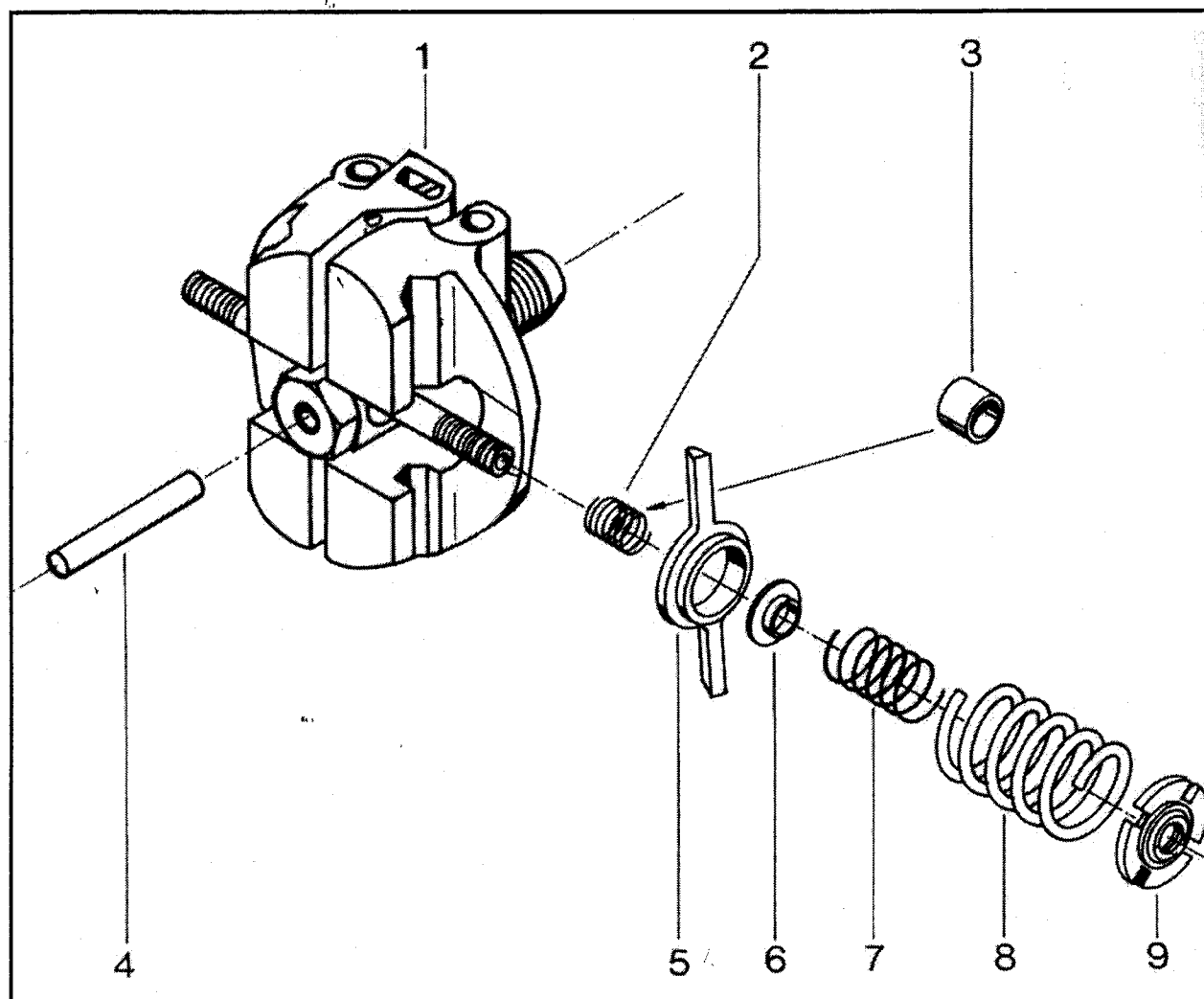


Figure 15

1. Governor body.
2. Midrange spring.
3. Spacer (instead

of 2 for
application).

generator

4. Governor pin.
5. Bridge.
6. Support.
7. Full load spring.
8. Idle speed
9. Cross slotted

spring.
nut.

The purpose of governor is to maintain constantly the specified speed of the engine. Therefore, centrifugal and resilient spring forces are used to monitor the amount of fuel injected by the injection pump.

According to the utilization of the engine, there are several types of governor:

1. Fixed full speed governor.

Only one speed (full load) is governed. For applications with constant speed operations such as generating sets.

2. Idle and full speed governor

(2- stage governor.)

Besides the full load speed the idling speed is also governed. For applications with constant speed operation and idle speed relief such as compressors, freezer units.

3. All speed governor (variable speed governor).

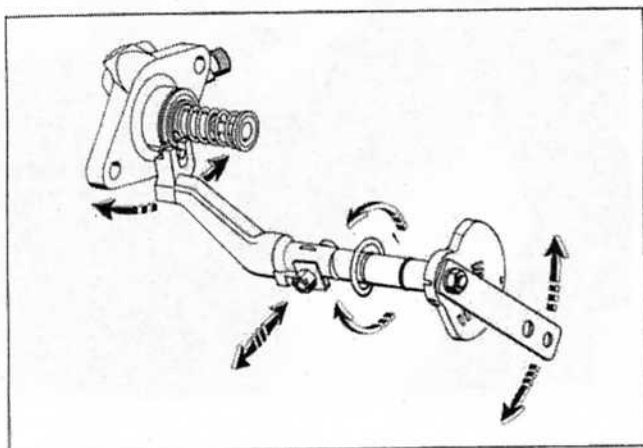
Governs the complete range of speeds from idle up to full speed. For applications with variable speed operation such as industrial engines, vehicle applications.

III.6.1. Construction and function of governor

The governor consists mainly of two flyweights and a set of springs which counteract the centrifugal force exerted by flyweights.

(Figure 15)

The governor being assembled onto the crankshaft, its speed is synchron with the engine speed. Its rotation drives the flyweights outwards and pushes a pin via a lever transmission against the adjustable tappet bolt of the control lever. Through this lever the injection pump fuel rack is pushed towards idle position. The control lever pivots on the eccentric regulation shaft.



Due to the control lever pivoting on the eccentric regulation shaft the distance between tappet bolt and governor pin increases when the acceleration lever is moved towards full load position. Thus enabling the small tension spring to push the control lever and the connected injection pump fuel load. More fuel means higher speed, i.e. the governor pin is being pushed out further and pressed again the tappet bolt, resulting in a movement of the control lever/fuel rack towards the idle position. Less fuel is injected the speed drops, governor pin moves back leaving a gap between tappet bolt and pin - and the complete governing loop starts again. Consequently the speed of the engine undergoes permanent oscillations, but these are so slight that only a very sensitive revolution meter would detect them.

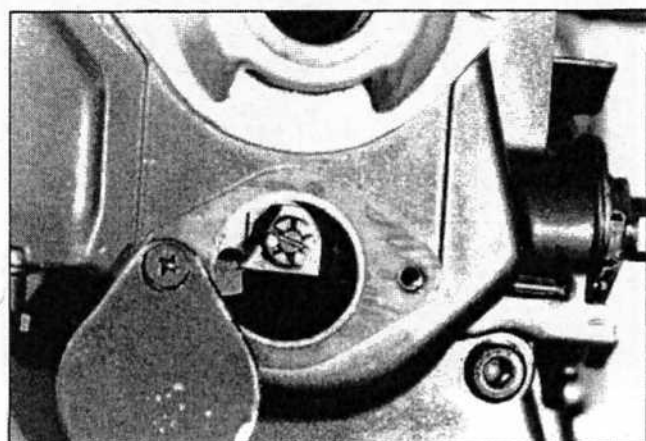
(Figure 16)

III.6.2. Governor setting

Each time the governor has been repaired and/or the gear cover or speed regulation assembly removed and reassembled, the governor must be reset, proceeding as follows:

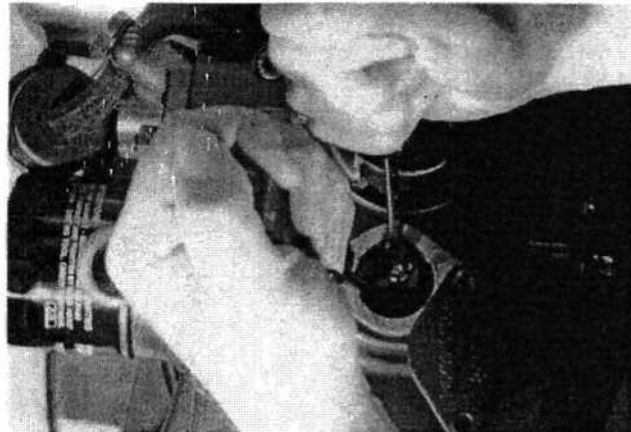
Remove the governor cover plate.

(Figure 17)



III. ENGINE REPAIR

Crank the engine¹ until the governor flyweights stand in a vertical position. Put the acceleration lever in full load position. Open the lock plate and loosen the castle nut. Screw in tappet bolt completely till tappet rests on control lever. Insert a screwdriver between the flyweights and force them apart to maximum opening. (Figure 18)



Now screw in the tappet bolt until it just comes in contact with the governor pin (no play to be felt when pushing onto the lever with your fingers.) Release the flyweights and screw in the tappet bolt half a turn further.

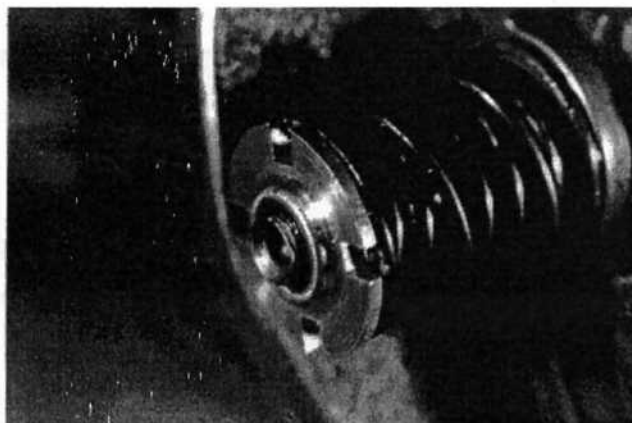
Maintain the screw in this position and tighten the castle nut, bend the lock plate and reassemble the cover plate. The correct setting of the clearance between tappet bolt and governor pin is essential for the proper function of the engine. If the clearance is too wide the engine can overspeed, is it too small the engine will not reach its full speed.

Speed adjustments in the range of ± 50 rpm are possible by altering the position of the cross slotted nuts. (Figure 19)

To increase speed - tighten the cross slotted nut.

To reduce speed - loosen the cross slotted nut.

Attention: The cross slotted nut must be at least flat with the end of the stud bolt. Otherwise the self securing effect of the nut is not working. Normally the stud bolt should protude out of the cross slotted nut.



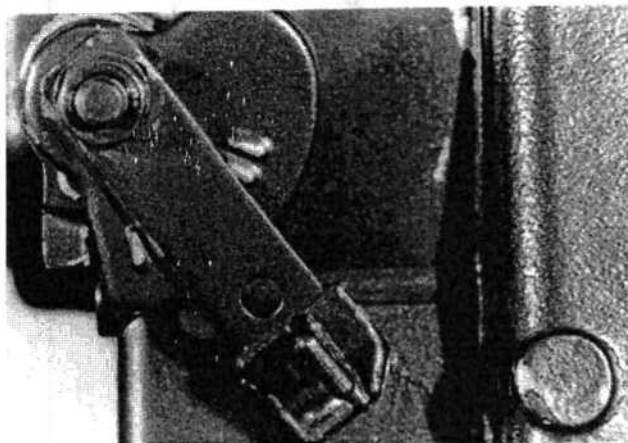
For larger speed variations the governor springs must be replaced. Replace the cross slottered nuts whenever a nut has been unscrewed. Every change in speed setting should be controlled on a test bench, or at least with a revolution counter.

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III.6.3. Acceleration lever

The acceleration lever is fixed in its position on the excentric shaft with a pin. The ratchet plate located behind the lever is not fixed and only kept in place by the M8 nut. As the ratched plate is used as a buffer for the engine shut down, the correct position between plate and lever is important. The lower edge of the lever should leave one and a half notches visible.

(Figure 20)



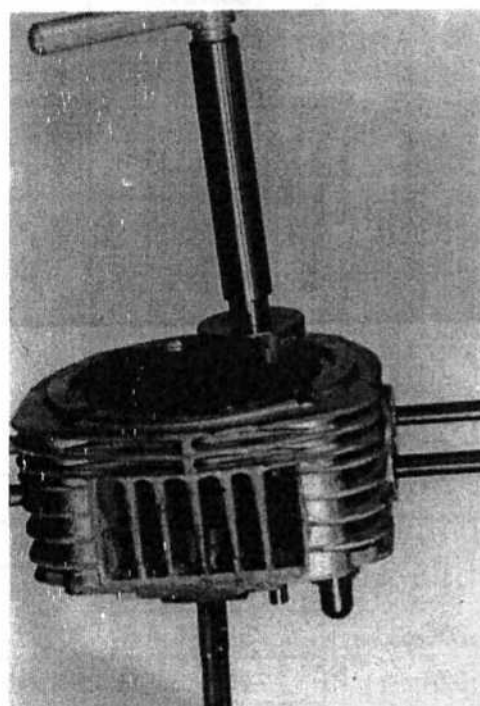
If more notches are visible the shut down of the engine may be hampered; if no notch is visible, damages (denting) on the control/eccentric shaft lever may occur.

To relocate the ratchet plate loosen M8 nut, hold the lever and move the plate till correct position is reached. Tighten the M8 nut while holding the lever, as otherwise the regulation linkage may be dented.

III.7. Resurfacing valve seats

The cylinder head is fitted with valve seat rings made of wear resistant steel. Should a resurfacing be necessary, use valve seat cutter. Simply insert guide pin (0.6.98 mm) into valve guide. Slide cutter over the guide and, while applying light pressure only, rotate the cutter with the T-handle.

(Figure 21)



Do not cut too deep. Observe the maximum permissible valves recess. After cutting the seat with fine grinding compound. To check the valve sealing, insert the valve and fill a small amount of diesel oil through the inlet resp. outlet channel. The sealing is ok when at a maximum 2 drops per minute leak out of closed valve.

This section is a guide to be possible location of the faults that may occur on an engine. Information of possible causes and suggested remedies are also given. But please note that this list can never be complete.

III.8. Adjustment – Injection pump – begin of delivery

Engine type	Flywheel-		Begin of delivery (mm) BTDC - Toleranz ±2mm engine speed (mm ⁻¹)							
	Part-No.:	dia- meter mm	1500	1800	2000	2500	2800	3000	3300	3600
15B/D	738.146.4	258						36	*	39
	738.149.4									
	738.158.4									
15B	738.160.4									
15B	738.174.4									
	738.181.4									
15D	738.185.4		*							
	738.219.4									
15D	738.223.4									
15B/D	738.237.4									
	738.254.4									
	738.255.4									
15B 15D	738.201.4	280						39	*	42
	738.225.4		*							
	738.305.4									
		738.221.4	285	*					40	
18B 18D	738.181.4	258						36	*	39
	738.185.4									
	738.208.4									
	738.226.4									
	738.236.4									
	738.238.4									
	738.244.4		*							
	738.254.4									
	738.255.4									
	738.257.4									
	738.259.4									
		738.218.4	298	*					42	*
29C 32A	738.304.4	280	41/38	*			57/55	*	66/66	
	738.270.4	304	44/41	*			62/59	*	72/72	
	738.298.4									
	738.210.4	308	45/42	*			63/60	*	73/73	
	738.291.4									
		738.284.4	350	51/48	*			72/68	*	83/83

III. ENGINE REPAIR

III.8.1 Adjustment - Injection pump - begin of delivery

Engine type	Flywheel-		End of delivery (mm) BTDC - Toleranz +2mm engine speed (mm ⁻¹)																					
	Part-No.:	dia- meter mm	1500	1800	2000	2500	2800	3000	3300	3600														
15B/D	738.146.4	258	*	18		21		27																
	738.149.4																							
	738.158.4																							
15B	738.160.4												21		27									
15B	738.174.4																							
	738.181.4																							
	738.185.4																							
15D	738.219.4																			21		27		
15D	738.223.4																							
	738.237.4																							
	738.254.4																							
15B/D	738.255.4																							
15B	738.201.4																							
	738.225.4																							
	738.305.4																							
15D	738.221.4	285	*	20		23		30																
18B	738.181.4	258	*	18		21		27																
	738.185.4																							
	738.208.4																							
	738.226.4																							
	738.236.4																							
	738.238.4																							
	738.244.4																							
	738.254.4																							
	738.255.4																							
	738.257.4																							
18D	738.259.4	258	*	*		*		20																
	738.218.4	298	*	21		24		31																
29C 32A	738.304.4	280	25			29	33	36		42														
	738.270.4	304	28			32	36	40		46														
	738.298.4																							
	738.210.4	308																						
	738.291.4																							
		738.284.4	350	32			36	41	45	*	*													

III.9 Torque specifications

	15B/15D/18B/18D			29C/32A		
	Spanner size (mm)	Tightening torque (Nm)		Spanner size (mm)	Tightening torque (Nm)	
		min	max		min	max
Cylinder head nuts	13	30	33	17	52	56
Connecting rod nuts	13	30	33	14	52	56
Valve cover nuts	13	8	12	13	8	12
Main bearing plate nuts	13	30	33	13	30	33
Fuel pump nuts	13	30	33	13	30	33
Delivery valve holder – fuel pump	14	34	39	14	34	39
High pressure fuel pipe nut – fuel pump	17	18	22	17	18	22
High pressure fuel pipe nut – injector	17	25	30	17	25	30
Injector clamp nuts	10	8	12	13	20	23
Governor on crankshaft	14	55	60	14	55	60
Flywheel, nut	36	216	226	46	390	410
Gear end cover screws	6	34	38	6	34	38
Tapped guide screws	4	8	10	4	8	10
Crank handle guide screws	10	8	12	10	8	12
Oil pump screws	5	16	20	5	16	20
Sump plate screws	Cross-slotted	9	11	Cross-slotted	9	11
Banjo bolt on fuel pump	17	25	35	17	25	35
Plastic nipple on injector	10	6	8	*	*	*
Banjo bolt on injector	*	*	*	11	8	10
Banjo bolt on tank	12	8	10	12	8	10
Oil filter	Hand-tighten!					

III. ENGINE REPAIR

IV.1. TROUBLE SHOOTING

This section is a guide to be possible location of the faults that may occur on an engine. Information of possible causes and suggested remedies are also given. But please note that this list can never be complete.

IV.2. Engine will not start

Reason	Causes	Remedy
<p>If squeak <u>cannot</u> be heard</p> <p>Fuel supply failure -check by cranking the engine and listen for the characteristic squeak in the injector.</p> <p>If squeak <u>can</u> be heard</p>	<p>No fuel in tank Acceleration lever at stop</p> <p>Vent bore in tank cap plugged Fuel line blocked</p> <p>Fuel filter clogged Broken fuel line or leaking connection Vapor lock (fuel too hot) Fuel too thick (no.2 in winter)</p> <p>Faulty injector nozzle</p> <p>Faulty injector pump</p> <p>Starting fuel button not pulled Gasoline instead of diesel in tank</p> <p>Air intake blocked</p>	<p>Fill tank only Set lever to full load Renew cap</p> <p>Check system, remove blockage Renew filter Renew pipe/tighten connections Cool the fuel Drain and flush system, fill with proper fuel Check/repair/renew nozzle Check/repair/renew pump</p> <p>Pull button</p> <p>Drain gasoline, flush system, fill with diesel Check system for blockage</p>
Poor compression	<p>Decompression device defect</p> <p>Incorrect valve clearance</p> <p>Valve not sealing properly</p> <p>Valves sticking Cylinder head loose Piston rings stuck in grooves Worn cylinder and piston</p>	<p>Check/renew decompression device Adjust valve clearance Check/repair/renew valves Free valves Tighten head nuts Check rings and clean the piston Overhaul the engine</p>
Difficult to crank engine	<p>Starting load too high Lub oil too thick</p> <p>Bearings seized Piston seized</p>	<p>Reduce load Change to correct viscosity Overhaul engine Overhaul engine</p>

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IV. 3. Engine starts but fires intermittently or soon stop

Faulty fuel supply	Fuel filter choked Fuel line choked Leaking fuel lines or connections Water in fuel Faulty injector nozzle Faulty injector pump	Renew filter Check lines for blockage/restriction Check lines, tighten connections Drain fuel, fill with clean fuel Check/renew nozzle Check/repair/renew pump
Faulty compression	Incorrect valve clearance Worn valves Valves sticking Piston ring stuck in grooves Worn cylinder and piston	Adjust valve clearance Overhaul cylinder head Free valves Check rings and clean piston Overhaul engine
Faulty exhaust and intake	Restricted/blocked exhaust Restricted/blocked intake	Check/clean exhaust system Check/clean intake system

IV. 4. Engine lacks power and /or smokes black

Operation conditions	Engine overloaded- Power reduction due to altitude and ambient temperature has not been observed	Reduce load
Faulty fuel supply	Gasket under injector missing or too many installed Fuel filter blocked Fuel injector nozzle Faulty injector pump	Correct number of gasket Renew filter Check/renew nozzle Check/repair/renew pump
Out of adjustment	Incorrect valve clearance Incorrect injection timing Complete timing incorrect Piston installed wrongly (18A/C only)	Adjust valve clearance Adjust injection timing Adjust engine timing correctly Correct piston installation
Dirty engine	Blocked air intake Excessive carbon on piston and cylinder head	Clean/renew filter Decarbonize
Engine condition	Faulty piston rings Worn out piston and cylinder Worn out bearings	Check/renew ring set Overhaul engine Overhaul engine

III. ENGINE REPAIR

IV. 5. Faulty running

Overheating	Engine overloaded Cooling fins clogged, flywheel air restricted Short circuit of cooling air Lub oil level too high Faulty injector nozzle	Reduce load Clean air passages, remove restrictions Improve cooling air flow (redesign application) Drain to proper level Check/repair/renew nozzle
Knocking	Carbon on piston crown Injector needle sticking Fuel timing too far advanced Broken piston ring Worn piston Worn bearings Loose flywheel	Decarbonize Fit new nozzle Adjust timing Fit new ring set Renew piston and liner Renew bearings Tighten flywheel nut
Speed is hunting	Overheating Air in fuel pipes Governor sticking Fuel filter choked	See above Check the system for leaking connections Free the governor Renew filter
Sudden stop	Empty fuel tank Vent bore in fuel tank cap plugged Vapor lock (fuel too hot) Choked injector Fuel pipe broken Seized piston Seized crankshaft	Fill tank Renew tank cap Cool fuel Renew nozzle Renew pipe Renew piston and liner Repair/ renew crank- shaft and bearings

III. ENGINE REPAIR

Blue smoke	Oil level in oil bath air filter too high Breather valve choked Oil seal at intake valve defect Worn valves/ valve guides Worn piston/ cylinder	Fill to proper level Renew breather Renew seal Renew valves and guides Renew piston and cylinder
White smoke	Fuel timing too late Injector nozzle worn out	Adjust timing Renew nozzle
Oil pressure warning lamp on	Oil pressure warning lamp is defect Oil level is too low	Exchange warning lamp Measure oil level, if necessary top up oil
Oil pressure is too low	Pressure valve is defect, ball place in the pressure valve is dirty. Oil filter is restricted lub oil pump is defect.	Check/clean if necessary renew